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ABSTRACT

A comparison is made of four maxicalculators and two minicomputers with an emphasis on two, the HP 9830 and the Wang 2200. Comparisons are in the form of a table with individual guidelines for analysis followed by the specific characteristics of the particular calculator. Features compared include: manual input facilities, screen, secondary storage system, central processing unit, software, hard copy, peripherals, support, and cost. The pros and cons of the 9830 and the 2200 are discussed. (DAG)

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Number 6

The Illinois Series on Educational Applications of Computers

A DETAILED COMPARISON OF MAXICALCULATORS

Richard Doring and Bruce Hicks

April 1976

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Preface

Maxicalculators (and their peripherals) are one type of small computer system. Even though these systems are small, the choice among them is still not a simple matter when the maxicalculators are to be used with the greatest effectiveness in educational applications, for then they must serve a great variety of students, teachers and administrators and in many different modes of operation.

Our discussion of the choice among maxicalculators concerns two aspects:

a) the capabilities of maxicalculators for the whole school;

b) an example of a detailed comparison between two maxicalculators.

The first aspect is covered in ISEAC paper Number 5 and the second in ISEAC Number 6.

These papers were based on a report by Richard Doring which was written in November 1975 for the Secondary Education course, "Computers for the Whole School" using the data on equipment, costs and capabilities that were then available to us. We believe that the criteria of choice he developed will still retain their validity even though these data are changed by the appearance of new or improved equipment. Nothing in the two papers is meant to imply recommendation by the authors or the Department of Secondary Education for purchase of any calculator or peripheral. The purpose of the papers is rather to discuss and illustrate the mechanics of choosing this computer equipment.

Other aspects of the choice among maxicalculators should be mentioned although they will not be discussed in the two papers. The relation between specific educational applications of maxicalculators and the capabilities of maxicalculators is an important and neglected aspect, but one that is difficult to treat with any generality. The quality of courseware and external software* supplied by the manufacturers clearly should affect the choice among maxicalculators. (Much of the courseware should be developed by each user school for its own specific needs.) Other considerations are the reliability of the calculator and its peripherals, the quality of maintenance service and the compatibility of the calculator with new peripherals and new modifications of the calculator.

Bruce Hicks
ISEAC Editor

*We use this term to designate the programs on cassette tapes as distinguished from those built into the calculators and their read-only memories.

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A Detailed Comparison of Maxicalculators

Richard Doring[a] and Bruce Hicks[b]

1. Introduction

An earlier ISEAC paper (1) described general criteria for comparing maxicalculators for educational applications in the whole school. Using Reference 1 as a starting point we make comparison, in the present paper, of four maxicalculators, and two minicomputers with emphasis on two, the Hewlett-Packard and the Wang. The comparison is in the form that might be produced by a typical high school (which we call Middletown High School). It must be remembered that different educational users will weight differently the importance of the various aspects of maxicalculator performance.

For convenience we repeat here the definition of maxicalculator given in Reference 1:

-portable, compact single-user computer
-immediate execution of arithmetic computations
-programmable in BASIC or APL (hard-wired)
-teletype-like keyboard with special purpose keys
-magnetic tape secondary memory (cassette or cartridge)
-optical display
-priced below $10,000 (without added peripherals)
-designed for adding on many peripherals that extend software, input-output, data communication and other capabilities

The detailed comparison of the two maxicalculators is shown in the Tables in the Appendix. In the first column of each Table are questions that can be used as guidelines for analysis of the characteristics of the maxicalculators. (For a checklist useful in selecting a terminal see Reference 2.) The second and third columns summarize the characteristics of the HP 9830 and the Wang 2200. (For detailed information see References 3 and 4.) The fourth column contains notes about unique features of other systems. Comments appear in the fifth column.

The strong points of the various systems are discussed in Section 2 and lead to overall conclusions given in Section 3.

It will be noticed that the Tables are not filled in completely. The Computer Study Committee of Middletown High School could not collect and interpret all of the necessary pieces of up-to-date data before the deadline set by the principal for choosing one of the available small computer systems. This incompleteness is not surprising in view of the variety of not precisely similar

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features found in the different systems and the limited time given to the Committee to finish its analysis.

The Committee also discussed the relative importance of the features of the various machines in implementing five different, specific instructional applications of computers (a minimal number of benchmarks!). Since there are more than 90 questions and other items among the guidelines in the Tables, the Committee was in effect trying to evaluate and weight some 450 individual judgments about the quality and suitability of the systems. The details of this part of their evaluation will not be given here. But the numbers just quoted (and the difficulty of setting benchmarks for instructional applications) support the claim made in the Preface, that careful choice of a maxicalculator system, for educational applications, is far from being a simple process.

2. Evaluation

HP 9830:

The HP 9830 is a maxicalculator that is very easy to use. It can be operated by beginners without computer experience after a very short introduction. Powerful system commands, few key presses, simple error correction, effective tape commands, clear structure of BASIC programs and extreme compactness are the highlights of this maxicalculator. The HP 9830 can be used best for introductory programming classes, for problem-solving and simulations for all classes and for small administrative jobs that do not need large memory or sophisticated input. With a disk drives* added it can be used for large administrative applications.

Wang 2200:

The Wang 2200 is a maxicalculator that is easy to use after a careful training period. Strong system commands, a fast CRT display, a powerful BASIC, exceptional input means, and inexpensive (floppy) disk drives are the strongest points of this maxicalculator. The Wang 2200 will be preferred by experienced programmers and by advanced students. With the floppy disk drive it may also be used for more than small administrative applications.

IBM 5100 (Provisional evaluation):

The IBM 5100 is a maxicalculator that is not very easy to use in the beginning. A large memory, choice of BASIC or APL** languages or both, and extreme compactness are the most valuable features of the IBM 5100. It seems that the IBM 5100 is most useful for scientific applications and data processing but less suitable for beginning programming classes.

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*The Hewlett-Packard disk drives are larger and more expensive than the Wang floppy disk drives.

**The computer language, APL, is more powerful and compact than BASIC and reduces programming time significantly. It is, however, used much less frequently in high schools than BASIC even though its use in grades four to twelve (as well as in commercial and scientific applications) has often been very successful.

Micro-Computer Machines MCM/700 (Provisional evaluation):

Except that it provides only APL and not BASIC, the MCM/700 seems to possess all the important capabilities of the IBM 5100 but in addition has a more powerful operating system and communication capabilities, and talks to many more peripherals.

DEC Classic (Provisional evaluation):

The Classic is a minicomputer that can be used like a time-sharing terminal, so it takes some time to train operators. The dual floppy disk and a low price seem to make it an inexpensive computer for instructional applications, for data processing and for administrative uses.

Altair 8800 (Provisional evaluation):

The Altair 8800, which is probably not so easy to use as the Classic, is the most inexpensive minicomputer on the market. It seems to be an extraordinary tool for computer science classes and advanced BASIC and assembler programmers.

3. Conclusions

Either the Hewlett-Packard 9830 or the Wang 2200 maxicalculators, costing less than $10,000 (see Section 2 of Reference 1), can provide computer service for the whole school. (See Reference 5 with regard to the central role of the students.) This computer service could include all instructional applications (except those requiring rapid access to large data bases or unusually long and fast calculations or computer graphics* and all small administrative applications.** These maxicalculators can also perform the larger administrative jobs but only slowly and with more complex systems programs and manipulations of the cassette tapes. Addition of floppy disks (like the Wang) with faster average access to data than for the cassette tapes would permit doing jobs that are larger by perhaps a factor of ten. Fixed head disks (like the Hewlett-Packard) making, say, 10 Mbytes*** of storage easily and rapidly available for processing would increase the capacity by perhaps another factor of three if the maxicalculators are not under great time pressure (for example, if the administrative applications can be run at night). For the larger administrative applications minicomputer systems, micro-processors and associated disk drives may be more efficient than the maxicalculator and may still be effective for the instructional applications, especially if a suitably powerful version of BASIC is available for both instructional and administrative applications (see (6) for example), and if the instructional and administrative uses are complementary and cooperative rather than competitive.

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*In the future, computer graphics can also be provided by a larger system based on a maxicalculator.

**A small administrative job is one that holds in fast memory and processes about 2000 numbers or 8000 characters of alphanumeric data; OR one that can be done conveniently by a number of such jobs in succession.

***M equals 1024^2 or about 1,000,000.

4.1 Terminal

Guidelines	HP 9830	WANG 2200/S	Other Computers	Comments*
a) Manual Input Facilities:				
What kind of keyboard?	Typewriter, calculator keys, special function keys, command keys	Typewriter, calculator keys, special function keys, BASIC statements, command keys	IBM, and MCM: APL statements CLASSIC: typewriter only Altair: typewriter, 10 command keys	BASIC statement keys are hard to find at first on the WANG
Are there keys for easy cursor control?	BACK, FORWARD (+ repetition); good	BACKSPACE & EDIT mode keys; very good		
Does a bell ring before end of a line?	Soft beep	No		Unimportant for WANG
Can input be buffered and modified later?	Yes. RECALL gets any line from memory	Yes. RECALL gets any line from memory		
Is the keyboard lockable?	No	No		May be important for schools
Is there an alerting means if an error occurs?	Soft beeping sound	No		
b) Screen				
What type of screen?	One-line plasma display, 80 characters, 32 at a time	CRT (9"), 16 lines, 64 chars. each	IBM 5100: miniature CRT MCM: 1 line, 85 chars., 32 at a time Altair: 1 line, 32 chars.	Must be considered very carefully vs. uses
How rapid is the display?	Instantaneous	Instantaneous (excellent)	CLASSIC: slow (60 chars./sec.)	WANG's display speed is very impressive
Is high speed scanning available?	Not possible	Fast page changing		
Can page-changing be performed?	No	Yes		
Is there a scroll feature?	Yes	No		
Is the image flicker-free?	Yes	Mostly		
Is it bright enough?	Yes	Mostly		
Is the cursor destructive/nondestructive?	Nondestructive	Destructive		

*The comments reflect the particular experience of the Computer Committee of Middletown School and their view of performance features needed in educational applications in their school, and could well be different in another school. Such comments, coming from students, teachers and administrators as well as manufacturers' representatives, are part of the mix that leads to successful choice of maxicalculators to match the needs of a particular school.

Guidelines	HP 9830	WANG 2200/S	Other Computers	Comments
Does it allow many cursor movements?	BACK, FORWARD & fast	BACKSPACE & EDIT mode		
Are the keys for cursor-movement reliable?	Yes	Yes		
Are enough characters available?	Yes	Yes	IBM, MCM: APL chars.	For normal applications
Can special characters be generated?	All ASCII characters	No		
Are the characters large enough?	Yes	No	IBM: Tiny characters MCM: Large characters	User must be very near to WANG screen
Are they easy to read?	Yes	No		
Does the screen allow graphic features?	No	No (Print at any position)		Maybe in future
Can a light-pen be used?	No	No		
c) Secondary Storage System:				
What kind of storage?	Magnetic tape cassette	Magnetic tape cassette	CLASSIC: dual (floppy) disk drive	
What size?	62K bytes/cassette	76K bytes/cassette	IBM: 200K bytes (cartridge) MCM: 100K bytes/cassette CLASSIC: 524K bytes	
Recording speed?	10 in/sec	7.5 in/sec		WANG appears to be very slow and annoying
Search speed?	26 in/sec	7.5 in/sec	CLASSIC: random access	
Rewind speed?	Fast	90 in/sec		
Bidirectional search?	Yes	No		
Pre-formatting necessary?	Yes (MARK)	No		A disadvantage of WANG?
Easy listing of file content?	Yes (T LIST)	No		
Powerful search commands?	Yes (FIND, LOAD)	Somewhat (SKIP, BACK-SPACE, LOAD)		
Is there a read or copy security?	Yes (SEC)	Yes (SAVE)		
d) Central Processing Unit:				
Size (read/write memory)	4K - 16K bytes	4K - 32K bytes	IBM: 16K - 64K MCM: 2 - 8K bytes CLASSIC: 32K	

Guidelines	HP 9830	WANG 2200/S	Other Computers	Comments
Cost of additional memory	$3760 for 12K	$3200 for 12K	Altair: $275 for 4K MCM: $1200 for 4K	
e) General:				
Is it portable?	Yes	Yes	IBM, MCM: highly portable CLASSIC: movable	
Is it silent?	Yes	Yes		
Is it compact enough?	Yes	No	Altair: many pieces	
Is there a way of terminal fault diagnosis?	Yes (tape)	?		

4.2 Software

Guidelines	HP 9830	WANG 2200/S	Other Computers	Comments
What languages are available?	BASIC	BASIC	IBM: APL/BASIC MCM: APL CLASSIC: BASIC, assembler Altair: BASIC, assembler	
Compiler or interpreter?	Interpreter	Interpreter	CLASSIC: compilers	Interpreter better for educational applications
Batch possible?	ROM necessary	Yes		
Direct commands/command language?	Keys for direct commands	Keys for direct commands	CLASSIC: command lang.	Direct commands better for educ.
Direct calculations mode?	Yes	Yes	CLASSIC: no	
User defined functions (selected by keys)	Yes	Yes	IMB, MCM: no	
Chaining possible?	Yes (LINK)	Yes (LOAD)		
Program length limits?	By memory size	By memory size		
Maximum number of users?	Interactive 1, batch > 20	Interactive 1, batch > 20		
Error diagnosing and debugging?	Good	Good		
Editing?	Very good	Good	IBM: not easy	
Interrupt feature?	STOP, STEP, CONT	STOP, HALT/STEP		
Input facilities?	INPUT	INPUT, KEYIN	IBM: wrong input Causes end of run	KEYIN is very powerful
Formatting?	WRITE, FORMAT	PRINT USING, % IMAGE, HEX PRINT		
String variables?	With ROM: 26 of length 255	286 of max.length 64		
Matrix operators?	ROM necessary	ROM necessary		

Guidelines	HP 9830	WANG 2200/S	Other Computers	Comments
Logical operators?	AND, OR, NOT	No		
Benchmarks: BASIC program with arithmetic arithmetic	30 sec.	24 sec.		Necessary for data processing

4.3 Hard copy

Guidelines	HP 9830	WANG 2200/S	Other Computers	Comments
Is hard copy essential for educational applications?	Yes	No		
Is hard copy separate from terminal?	Yes	Yes	CLASSIC: no	
How rapid is printing?	Fast	Fast with line printer	CLASSIC: slow	
What kind of printer?	Thermal printer	Line printer	CLASSIC: electrolytic	Cost of printers are high
Cost of paper?	High	Low	CLASSIC: ?	
Can printer be switched off?	Yes + PRINTALL	Yes		
What noise is encountered?	None	Much		
Strong movement of printer?	None	Very disturbing		

4.4 Other peripherals

Guidelines	HP 9830	WANG 2200/S	Other Computers	Comments
Additional magnetic tape drives	Yes (cassette)($1885)	Yes ($1200) (cassette)	IBM: Yes (cartridge)	
Disk?	Dual Platter ($13,645)	Single Floppy Disk ($3,200)		
Mark sense/punched card reader?	Yes ($3,125)	Yes ($4,800)		WANG not demonstrated
Instruments to mark?	Soft lead pencil	Special ink		
Connection to large computer and data lines?	Good	Possible	MCM: Yes	
Access to peripherals complicated?	No	Somewhat	MCM: No	

4.5 Support (see (7))

Guidelines	HP 9830	WANG 2200/S	Other Computers	Comments
Textbooks? or training?	Easy instructions (no training)	Corporate training staff	CLASSIC: Yes	

Guidelines	HP 9830	WANG 2200/S	Other Computers	Comments
Self-instructional programs?	No	No	CLASSIC: Yes	Experience with maxicalculator sales people indicates that they are not very familiar with education market
Pré-written application material?	Entire HP library (large)	Not much in education	CLASSIC: Excellent	
User group?	Well organized	SWAP	CLASSIC: Good	
Sales people?	?	?		
Maintenance?	?	?	?	

4.6 Basic installations

HP 9830		Prices Nov. 1974
9830A Calculator (3,520 bytes		$ 6,800
7,616 total bytes		$ 1,600
Thermal Printer		$ 3,145
Hopper-feed Mark/Punch Card Reader		$ 3,125
ROMS:	Batch Basic	$ 525
	String Variables	$ 525
	Extended I/O	$ 525
	Matrix Operations	$ 525
Basic HP 9830 installation		$16,770

WANG 2200/S		Prices Nov. 1975
2200S-1	CPU (4,096 bytes)	$ 2,400
	Additional 4,096 bytes	$ 1,200
2220	Console-CRT/Keyboard/Tape	$ 3,000
2231	Line Printer (80 column)	$ 3,300
2244A	Hopper-feed Mark/Punch Card Reader	$ 4,800
	ROMS	
OP-20	Up to 6 I/O slots	$ 600
OP-21	Matrix ROM	$ 300
Basic WANG 2200/S installation		$15,600

4.7 Pros and cons

HP 9830	WANG 2200/S
Thermal printer - fast and quiet	Line-printer - noisy
Output with or without PRINTALL	Output either on display or on printer
Listing of program on paper (high cost!) for just looking at BASIC program	High-speed scanning through program without printout for just looking at program
Lowest line on printer output hard to read	Readability of screen poor
Panel - line very easy to read	Standard file size (256 bytes), no creating
Any file sizes on tape can be created	No fast search, use REWIND to go backward
Fast search forward and backward	Error detection with arrow ↑ for position
Error detection without arrow for position	In-line error correction: several keypresses before editing
In-line error correction: one keypress before editing	Commands less powerful (more keypresses) and requiring more understanding of computers
Commands powerful (few keypresses)	

5. References

1) Doring, R. and Hicks, B., Maxicalculators for the Whole School, ISEAC Number 5, College of Education, University of Illinois at Urbana, April 1976.

2) Martin, J., Design of Man-Computer Dialogues; Prentice Hall, Englewood Cliffs, New Jersey: 1973.

3) Hewlett-Packard 9830A Calculator, Operating and Programming; Loveland, Colorado: 1973.

4) WANG, 2200A/B BASIC Programming Manual; Tewksbury, Massachusetts: 1974.

5) Hicks, B., Goddard, W. and Keasler, L., Students: Where the Action Is, ISEAC Number 3, August 1975.

6) Hopperton, J., Registration Can Be Fun--A Small Computer Can Do It All, THE Journal (Technological Horizons in Education), Volume 2, No. 8, December 1975.

7) Whitney, R., Buyer's guide to instructional computing, People's Computer Company, Vol. 2, Number 4, March 1974, pp. 3-6.

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